PV Module Hotspot Detection

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Abstract

Hotspot defects are known to cause reliability problems in both thin-film and conventional c-Si modules. Detection of hotspots in completed modules can identify potential failures before the module is installed in the field. We describe several root causes for hotspot failures in PV modules, and demonstrate an infrared measurement technique, IRIS™, to quickly identify and characterize the severity of module hotspots.

Background

Hotspots are, in general, most noticeable when a cell is placed in reverse bias. As an example, consider the c-Si module shown below.

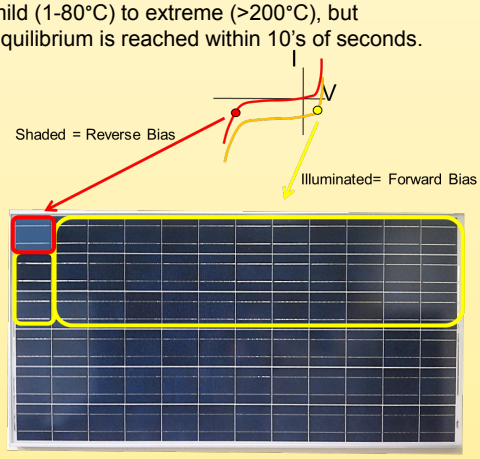
Assume that one cell (outlined in red) is shaded while all other cells are fully illuminated.

Causes of shading might include:

- Bird or Leaf
- Dirt or Snow
- Building Shadow… etc.

A shaded cell with minor defects will readily withstand the high reverse bias (~10-12 Volts, typical) that persists until the shadow is removed, but a cell with significant shunts will leak reverse current and exhibit extremely localized heating at each defect.

The temperature rise near a defect can vary from mild (1-80°C) to extreme (>200°C), but equilibrium is reached within 10's of seconds.



Hotspots: Common Causes

Cell Manufacture

- Incomplete edge isolation
- Crystalline defects intersecting junction
- Metal-decorated cracks
- Overfiring: pn junction "punchthrough"
- Scribeline shunts- incomplete removal or redeposition
- Metal particles & bridges on backside
- Print alignment errors

Module Manufacture

- High resistance or "cold" solder points
- Current mismatch between cells

Typical Damage (x-Si)

Mild (<80°C rise)

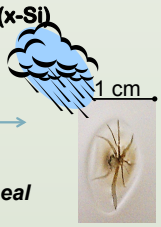
- Low damage probability

Moderate (~80-200°C rise)

- Backsheet bubbles
- Coverglass cracking
- ***loss of quasi-hermetic seal***

Extreme (>200°C rise)

- Cell damage



Long term effect

Moisture Intrusion
→ Corrosion & Power Loss
→ Warranty failure.

Manufacturing Requirement

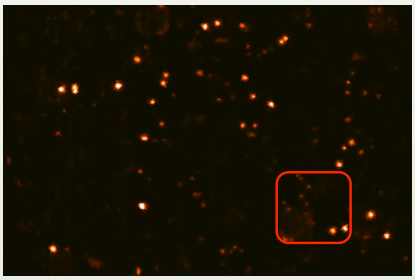
- Reduce Warranty Exposure by identifying hotspot modules with high reliability (>99.9% accurate) inspection.

Module Measurement Method

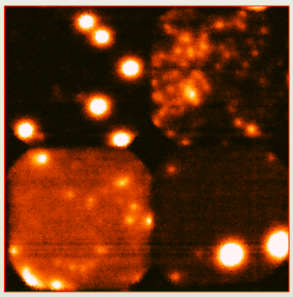
Method: Lock-in & Time-resolved Thermography[Patents Pending]

Camera: LWIR (8-12 micron)

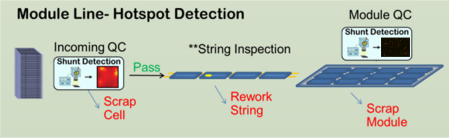
Speed: a) Inline: ~20 seconds / module
b) R&D: 30ms- 5 min.



Complete Module Inspection



Analysis of Module Regions



Summary

Using this technique, hotspots may be conclusively identified before or during field installation with IRIS inspection machines capable of >25 modules per hour. The technique works in ambient light and directly measures the local heating due to defects.

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Process Control for PV